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RECOVERY OF STREAM BENTHOS FROM DISTURBANCE RESULTING FROM A NATURAL FLOOD

BY

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Final Report

for

Recovery of Stream Benthos from Disturbance Resulting from a Natural Flood

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ABSTRACT

In mid August, 1977 a flash flood disrupted the benthic community of one of two forks of Tesuque Creek, Santa Fe National Forest, New Mexico. A study of the disturbed stream was undertaken to 1) determine the rate of recovery of the benthos and 2) compare the rates of recovery of benthos upstream and downstream from the undisturbed fork of Tesuque Creek. One year after the flood, no significant differences were detected between flooded and unflooded sites in biomass, numbers of individuals, or numbers of species. However, some differences in composition of the benthos remained. The Trichoptera and Coleoptera appeared to recover most slowly from the effects of the flood. It is suggested that these two orders may be useful as indicators of the flow stability of streams. Recovery appeared to proceed at approximately equal rates upstream and downstream from the undisturbed fork.

Introduction

In mid-August 1977 a flash flood disrupted a study being conducted on Tesuque Creek, Santa Fe National Forest. That study was designed to ". . . determine rates of stream sedimentation due to road maintenance and consequent effects on stream invertebrates." However, the flood eroded away 0.6 to 1 m of streambed in some sections of Tesuque Creek, cut new channels in other sections, and filled the ponding basin behind the U.S. Geological Survey wier on the creek with approximately 2 m of sand, gravel, and boulders (some weighing over 70 kg). As a consequence of the flood, sedimentation patterns resulting from road maintenance were disrupted and numbers of benthic intertebrates reduced to 6% of previous levels. It was therefore impossible to meet the objectives of the original study. However, an alternative set of objectives was suggested.

It is generally known that flooding of sufficient intensity disrupts stream benthos (e.g., Anderson and Lehmkuhl, 1968; Hynes, 1968; Waters, 1972). Rarely, however, have suitable control sites existed to enable accurate estimates of rates and manner of recovery of stream benthos. A year of quantitative sampling of the benthos of Tesuque Creek provided the necessary baseline data on the structure of the benthic community prior to the flood. Further, the pattern of flooding provided a suitable control site. Approximately 250 m upstream from the disturbed study site Tesuque Creek divides into north and south forks (Fig. 1). Only the south

fork received sufficient precipitation to flood, leaving the north fork undisturbed.

Objectives

The objectives of this study were to 1) determine the rate of recovery of stream benthos from disturbance resulting from a natural flood and 2) compare effectiveness of downstream versus upstream movement of benthos as means of recolonizing disturbed stream communities.

Methods

The study stream, Tesuque Creek, flows out of the Sangre de Cristo Mountains and is crossed by a road to the Santa Fe Ski Basin approximately 12 km northeast of Santa Fe, New Mexico. Four study sites were established on Tesuque Creek above that road (Fig. 1). Each study site included a 60 m reach of the creek. The first study site which had been sampled for a year prior to the flood, extended upstream from a point approximately 250 m below the confluence of the flooded and unflooded forks of Tesuque Creek. The control site was on the north fork of Tesuque Creek, extending upstream from the confluence of the north and south forks. The third site was on the south fork and began 250 m above the confluence and the fourth site, also on the south fork, extended upstream from a point 500 m above the confluence. It was expected that the undisturbed north fork would be a source of invertebrates for recolonization of the remainder of Tesuque Creek. The establishment of study sites above and below the north fork

was intended to provide a comparison of the rates of recolonization by downstream versus upstream movement of organisms.

Study sites were sampled using a Surber sampler (.093m^2) with 0.25 mm mesh. Samples were taken in midstream from the nearest riffle at intervals of 5 m beginning at the downstream end of each study site. When sampled, twelve Surber samples were taken at each site. The sections of stream studied consisted chiefly of swift runs with little pool development. Study site 1 was sampled five times during the study. Study sites 2-4 were sampled 3 times, 2 months after the flood, 9 months after and 1 year after the flood. Limited funds prevented sorting of all samples taken one year after the flood.

Samples were fixed in 95% ethonol in the field. Invertebrates were transferred to 70% ethanol at the time of sorting. Sorting, identification, counting and weighing of invertebrates were done in the laboratory. Dry weights of invertebrates were taken by drying specimens with an infrared drying unit, cooling them in a dissicator, and weighing on a semi-micro balance (precision = $\pm$ .01 mg).

Because much of the data did not meet the assumptions of parametric tests, statistical comparisons of study sites were made using the Mann-Whitney test or the Kruskal-Wallis test with a procedure for multiple comparisons (Zar 1974).

Results and Discussion

During the study, nearly 39,000 stream invertebrates were collected, identified, counted and weighed. Most of these, ~98% were insects of the orders Ephemeroptera, Plecoptera, Trichoptera,

Coleoptera, and Diptera. The remainder were oligochaetes, turbellarians, and nematodes. Of these last three groups, only the oligochaetes were collected in sufficient numbers to be included in the analyses.

Numbers and Biomass

Total numbers and biomass of invertebrates in the Tesuque were severely affected by the flood in mid-August 1977. Two weeks after the flood the average number of invertebrates per Surber sample (.093 m^2) at the 250 m-below site was only 5.75 (Table 1, Fig. 2). One year before at the same site the average per sample was 91.40 (Molles 1978). Approximately one month after the flood, total numbers had increased to 23.42 per sample, comprising on the average 5.6 mg dry wt. (Table 1, Fig. 1 and 2). One month later all 4 study sites were sampled. The 250 m-below site yielded on average of 217.91 organisms per sample, an approximately ten-fold increase from the previous sampling period. However, numbers per sample were significantly higher at the undisturbed site ($\bar{x}$=706.83, $P<.001$). Numbers per sample at the 250 m-below ($\bar{x}$=217.91) and 250 m-above ($\bar{x}$=263.42) sites were not significantly different ($P>.10$). The numbers collected at the 500 m-above site ($\bar{x}$=440.83) were significantly greater than at either the 250 m-below or the 250 m-above site ($P<.001$). This result was unexpected. It might indicate less immediate impact of the flood on the 500 m-above site or more rapid recovery. On the other hand the uppermost site might be more productive than the lower sites for some other

reason (e.g. substrate differences). However, numbers at the 500 m-above site were still significantly less than at the undisturbed site ($\bar{x}$=706.83, P<.001).

Biomass at the 250 m-below site had increased after 2 months to 28.03 mg. However, despite this seemingly dramatic increase, the weight of organisms per sample was significantly greater at the 250 m-above ($\bar{x}$=41.58), and 500 m-above sites ($\bar{x}$=85.24, P<.05 and P<.001 respectively). Surprisingly, biomass at the 500 m-above site was greater than at the undisturbed site ($\bar{x}$=59.00, P<.001). This result was not repeated in a later collection.

By May 1978 (9 months after the flood), numbers at the 250 m-below site had increased to 51.58 per sample. However, again, significantly greater numbers were collected at the other sites on the disturbed fork ($\bar{x}_{250}$=124.25, $\bar{x}_{500}$=131.33, P<.001). However, the control site yielded even more invertebrates per sample ($\bar{x}$= 235.92, P<.001).

Biomass patterns 9 months after the flood were very different from patterns of Numbers. No significant differences between study sites on the disturbed fork were detected (P>.5). The greater numbers at the upper sites resulted from large numbers of small chironomid (Diptera) larvae. All three sites on the undisturbed fork produced significantly less biomass per sample than the undisturbed site (P<.001).

After one year no significant differences in total numbers or biomass could be detected between the undisturbed and the 250 m-below sites (P>.20 and P>.10 respectively). However, some differences remained in composition of invertebrates at the two sites (Table 1).

Insufficient funds remained at the end of the study to support the processing of samples taken one year after the flood at the 250 m-above and 500 m-above sites.

The recovery of individual taxa varied greatly (see Table 1). Oligochaetes showed no significant differences between sites on any sampling date. This was largely the result of high sample variance.

Ephemeroptera and Plecoptera showed trends similar to each other. Two months after the flood both were collected in highest numbers at the undisturbed site ($P<.001$) and the 250 m-below site produced more individuals per sample than either study site above the control site ($P<.05$). The patterns of biomass distribution in October, 1977 were essentially the same as patterns of numbers except that there were no significant differences in Plecopteran biomass among the flooded sites ($P>.5$). Nine months after the flood both Plecopteran and Ephemeropteran biomass and numbers remained highest at the undisturbed site ($P<.001$) while no significant differences were found among the other sites ($P>.1$). However, twelve months after the flood the control and 250 m-below sites showed no significant differences in numbers or biomass of these two insect groups ($P>.05$). These patterns of recovery for Plecoptera and Ephemeroptera parallel closely the pattern of recovery of total numbers and biomass discussed above.

The Diptera showed patterns of distribution which contrasted sharply with the patterns observed for Plecoptera and Ephemeroptera. Two months after the flood Diptera were collected in largest numbers at the 500 m-above site ($P<.001$). Diptera biomass was also

highest at the uppermost site in October 1977 ($P<.01$). Further, though no significant differences in numbers of Diptera were found between the 250 m-above site and the undisturbed site ($P>.20$), biomass per sample was significantly higher at the 250 m-above site ($P<.001$). The 250 m-below site yielded the lowest biomass and numbers of Diptera in October. After nine months, numbers of Diptera at the undisturbed site did not differ significantly from numbers at the 250 m-above site ($P<.05$) and exceeded numbers at the 500 m-above site ($P<.05$). In further contrast to the October collections, in May, Diptera biomass was highest at the undisturbed site ($P<.001$). Nine months after the flood Diptera biomass and numbers remained lowest at the 250 m-below site. However, one year after the flood, Diptera biomass and numbers at the control and 250 m-below sites did not differ significantly ($P>.10$).

The Trichoptera and Coleoptera seemed to be the most severely affected groups. Numbers and biomass of both the Trichoptera and Coleoptera remained highest at the undisturbed site throughout the study ($P<.002$ and $P<.05$ respectively). This result seems to single out these two orders as possible indicators of flow stability. This possibility merits further investigation.

Species Number

Species number and composition appeared to be affected much less than biomass or numbers. This conclusion is reached through a comparison of samples taken from the 250 m-below site after the flood with samples taken at the same site a year before the flood

and with samples taken at the undisturbed site (Table 2, Fig. 4). Because of taxonomic difficulties, diptera and oligochaetes were excluded from this analysis.

A year prior to the flood, 25 species were collected in twelve Surber samples taken at the 250 m-below site. Two weeks after the flood, 16 species were collected, and one month after, 12 Surber samples contained 15 species. By October, the number of species at the 250 m-below site had increased to 19 compared to 23 species collected at the control site. In May 1978 the number of species collected decreased at both control (19 species) and 250 m-below sites (11 species). A year after the flood, as with numbers and biomass, number of species at the 250 m-below site attained a level similar to the control site. During that collection, 23 species were collected at the control site and 24 at the 250 m-below site, 1 less than were collected at the same site one year before the flood.

A year after the flood, species composition at the 250 m-below site also seems to have returned to preflood conditions. Some differences in composition between sites and times remained. However, too little is known concerning the relative importance to the distribution of benthic insects of factors such as subtle habitat differences and chance. Therefore, these small compositional differences between collections cannot be discussed in a meaningful way.

Downstream Versus Upstream Recolonization

The results of this study indicate that colonization proceeded

at approximately equal rates above and below the undisturbed fork of Tesuque Creek.

In comparisons of upstream and downstream sites, only the plecoptera and ephemeroptera were represented by larger numbers and/or biomass at the 250 m-below site and this result was limited to the October collections. Further, this difference was balanced by Diptera being more abundant at upstream sites during both October and May. These results support the conclusions of Williams (1977) and Williams and Hynes (1976) that both upstream and downstream movement are important sources of colonists in streams. It is unfortunate the we were unable to process all samples taken one year after the flood. Those collections would certainly shed more light on the question of the relative importance of downstream versus upstream recolonization.

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Table 1. Comparisons of numbers and biomass of invertebrates collected in Tesuque Creek at the 250 m-below, 250 m-above, 500 m-above, and undisturbed study sites. The values listed are means of 12 Surber samples (.093 M^2). Statistical comparisons were made within collecting dates only. Means with different superscripts are significantly different ($P<.05$).

			10-10-77 (2 months)				5-18-78 (9 months)				8-31-78 (12 months)	
Numbers	250 m-below 8-29-77 (.5 month)	250 m-below 9-12-77 (1 month)	Undisturbed (Control)	250 m-below	250 m- above	500 m -above	Undisturbed North Fork (Control)	250 m-below	250 m-above	500 m-above	Undisturbed (Control)	250 m-below
Oligochaeta	.17	.58	2.42[a]	1.25[a]	.83[a]	1.83[a]	10.42[a]	5.50[a]	15.33[a]	26.83[a]	3.83[a]	2.58[a]
Ephemeroptera	.58	4.50	278.92[a]	60.17[b]	3.83[c]	2.50[c]	55.25[a]	12.08[b]	6.83[b]	14.83[b]	153.25[a]	229.25[a]
Plecoptera	1.17	2.66	96.17[a]	16.50[b]	8.58[c]	8.08[c]	19.50[a]	.67[b]	2.42[b]	3.25[b]	71.25[a]	67.58[a]
Trichoptera	1.42	2.50	101.00[a]	7.67[b]	11.42[c]	4.92[b]	16.58[a]	.75[b]	1.08[b]	2.08[b]	52.42[a]	7.00[b]
Coleoptera	.08	.33	24.50[a]	.5 [b]	0 [b]	0 [b]	3.08[a]	0 [b]	0 [b]	0 [b]	13.67[a]	1.33[b]
Diptera	2.08	13.25	216.67[a]	120.17[b]	238.17[a]	422.25[c]	116.42[a]	31.58[b]	96.42[a]	81.75[c]	248.50[a]	164.33[a]
Total	5.75	23.42	706.83[a]	217.91[b]	263.42[b]	440.83[c]	235.92[a]	51.58[b]	124.25[c]	131.33[c]	467.08[a]	543.91[a]
Biomass (mg Dry Wt.)												
Oligochaeta	-	.17	4.40[a]	12.04[a]	7.79[a]	25.58[a]	16.67[a]	2.22[a]	.18[a]	1.14[a]	9.47[a]	20.78[a]
Ephemeroptera	-	.62	19.14[a]	2.42[b]	.23[c]	.35[c]	10.94[a]	2.60[b]	2.25[b]	2.27[b]	11.59[a]	24.40[a]
Plecoptera	-	.24	8.22[a]	.73[b]	.77[b]	1.07[b]	12.43[a]	.18[b]	.46[b]	.81[b]	13.52[a]	7.61[a]
Trichoptera	-	3.89	20.69[a]	6.83[b]	3.16[b]	4.64[b]	20.60[a]	.15[b]	.26[b]	2.79[b]	28.72[a]	4.33[b]
Coleoptera	-	.30	2.91[a]	.04[b]	0 [b]	0 [b]	1.05[a]	0 [b]	0 [b]	0 [b]	1.19[a]	.14[b]
Diptera	-	.23	4.55[a]	5.78[a]	29.12[b]	52.81[c]	8.16[a]	2.95[b]	5.19[c]	7.10[c]	5.37[a]	4.61[a]
Total	-	5.6	59.00[a]	28.03[b]	41.58[c]	85.24[d]	69.90[a]	8.09[b]	8.64[b]	14.63[b]	69.99[a]	62.06[a]

Table 2. Species composition and number at the 250 m-below study site before and after the flood compared with species composition and number at the undisturbed site 12 months after the flood.

	Time After Flood						
	1 Year Before	2 Weeks	1 Month	2 Mos	9 Mos	1 Year	Undisturbed Fork
EPHEMEROPTERA	7/31/76	8/29/77	9/12/77	10/10/77	5/18/78	8/31/78	8/31/78
Baetidae							
Baetis bicaudatus	X	X	X	X	X	X	X
Baetis sp.	X					X	X
Ephemerellidae							
Ephemerella coloradensis	X		X	X	X	X	X
E. doddsi	X			X		X	X
E. inermis	X	X		X	X	X	
Heptageniidae							
Cinygmula sp.	X	X		X	X	X	X
Epeorus longimanus	X					X	X
Rithrogena sp.	X	X		X	X	X	X
Siphlonuridae							
Ameletus sp.							X
COPTERA							
Chloroperlidae							
Sweltsa spp.	X	X	X	X	X	X	X
Nemouridae							
Prostoia besametsa				X			
Zapada haysi	X	X	X	X	X	X	X
Perlidae							
Hesperoperla pacifica	X		X				
Perlodidae							
Megarcys signata	X					X	X
Kogotus modestus	X	X		X		X	X
Isoperla ebria	X	X	X	X		X	X
I. fulva	X	X				X	X

	Time After Flood						
	1 Year Before	2 Weeks	1 Month	2 Mos	9 Mos	1 Year	Undisturbed Fork
TRICHOPTERA	7/31/76	8/29/77	9/12/77	10/10/77	5/18/78	8/31/78	8/31/78
Brachycentridae							
Micrasema sp.		X				X	
Glossosomatidae							
Glossosoma sp.						X	X
Hydropsychidae							
Arctopsyche grandis	X		X	X		X	X
Limnephilidae							
Ecclisomyia conspersa							X
Limnephilus sp.	X					X	
Neothrema sp.	X	X	X	X	X	X	X
Oligophlebodes sp.	X					X	
Philopotamidae							
Dolophilodes sp.			X				
Rhyacophilidae							
Rhyacophila acropodes	X	X		X		X	X
R. alberta	X			X			
R. angelita		X	X	X	X	X	X
R. hyalinata	X	X	X	X	X		X
R. verrula					X		
Rhyacophila sp.		X	X	X		X	
COLEOPTERA							
Elmidae							
Heterlimnius corpulentus	X	X	X	X		X	X
Heterlimnius sp.	X						X
Narpus concolor	X		X				
Hydrophilidae							
Helophorus sp.			X				
Number of Species	25	16	15	19	11	24	23

Figure 1. Map of study sites on Tesuque Creek in the Santa Fe National Forest, New Mexico.

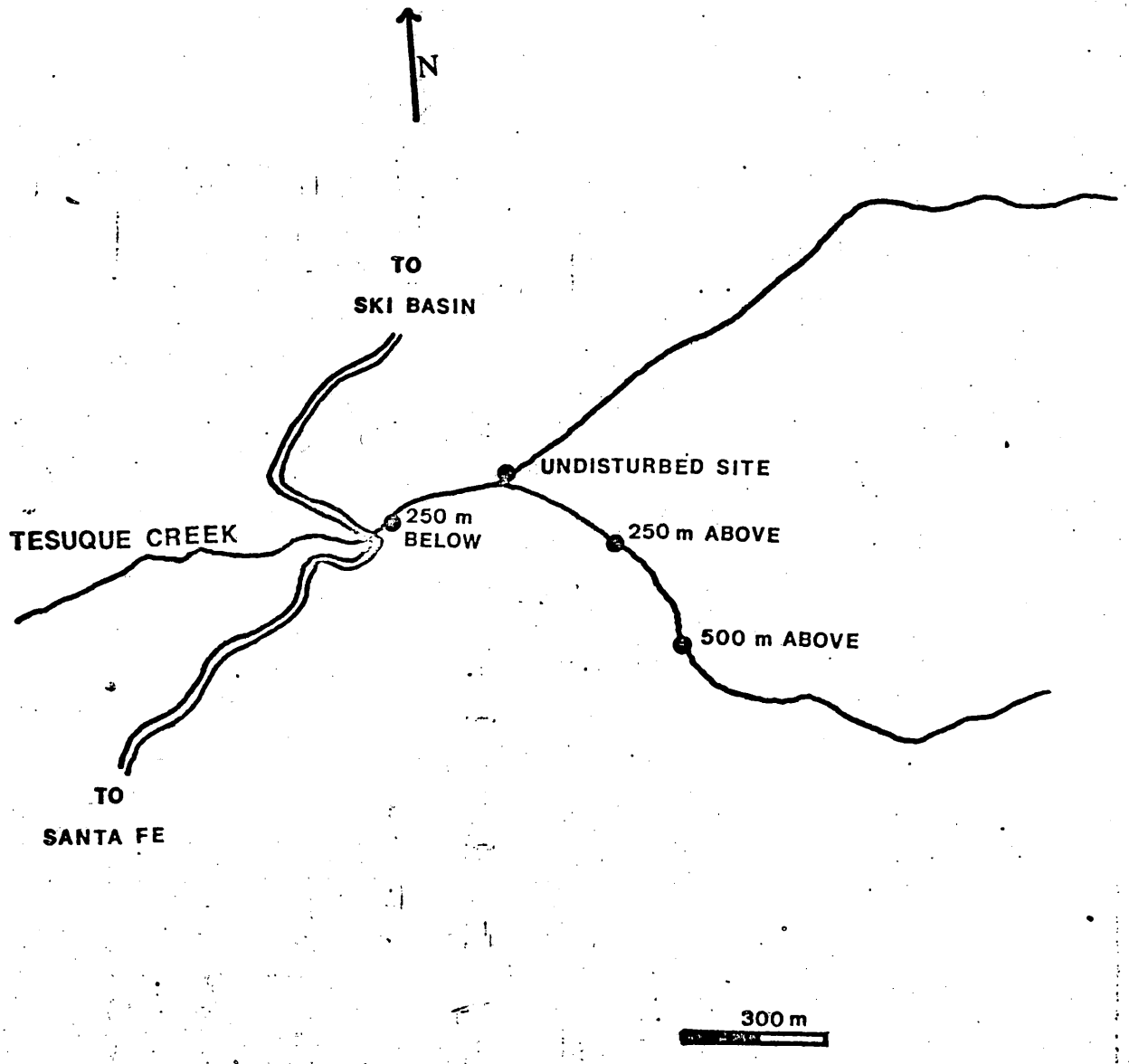

N
TO
SKI BASIN
UNDISTURBED SITE
TESUQUE CREEK
250 m
BELOW
250 m ABOVE
500 m ABOVE
TO
SANTA FE
300 m

Figure 2. Mean number of invertebrates per Surber sample (.093 m^2) at the 250 m-below and undisturbed study sites. An * indicates significant differences between sites ($P<.05$).

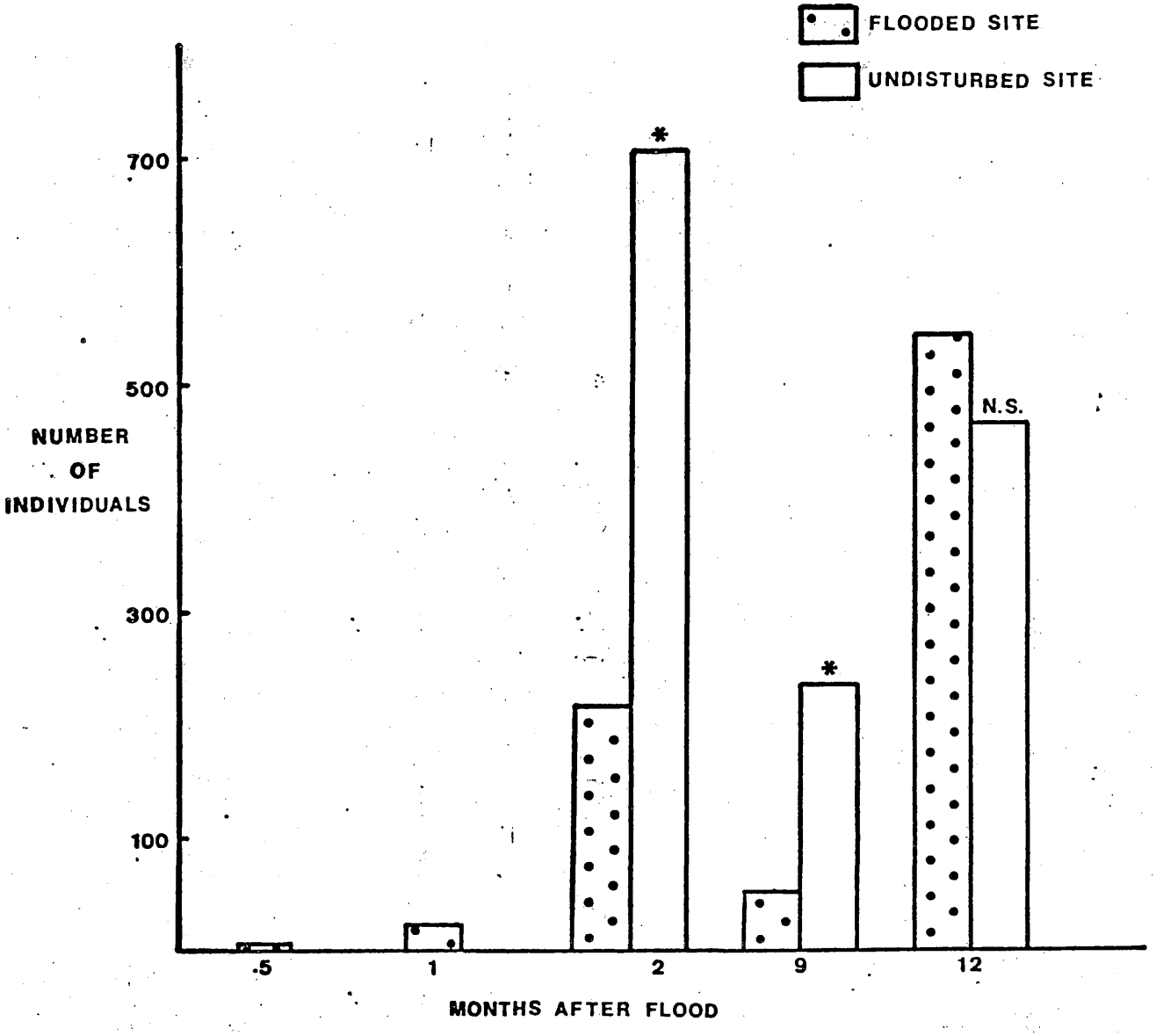

FLOODED SITE
UNDISTURBED SITE
700
500
300
100
NUMBER OF INDIVIDUALS
*
*
N.S.
.5
1
2
9
12
MONTHS AFTER FLOOD

Figure 3. Mean dry weight of invertebrates per Surber sample (.093 m^2) at the 250 m-below and undisturbed study sites. An * indicates significant differences between sites ($P<.05$).

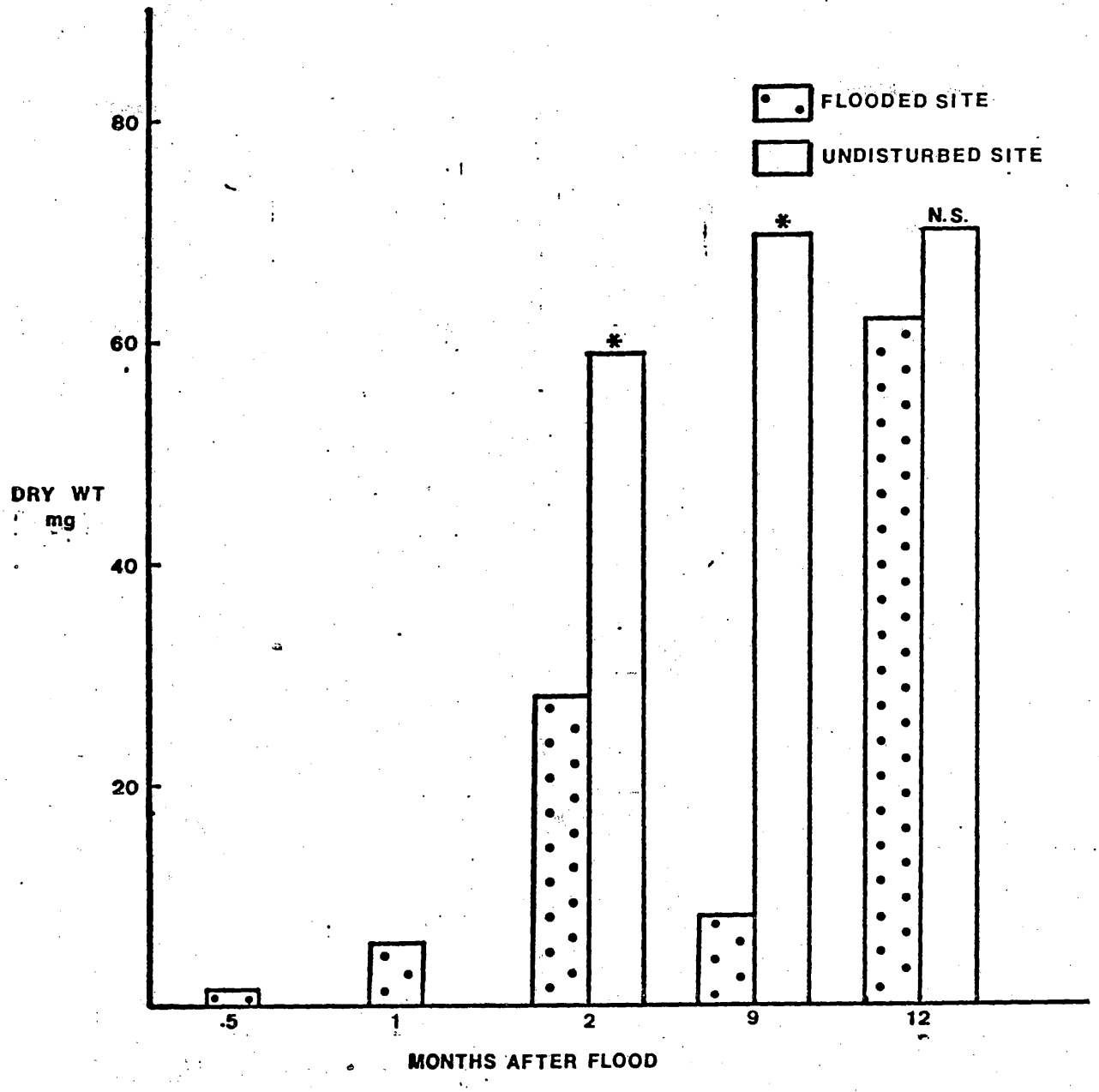
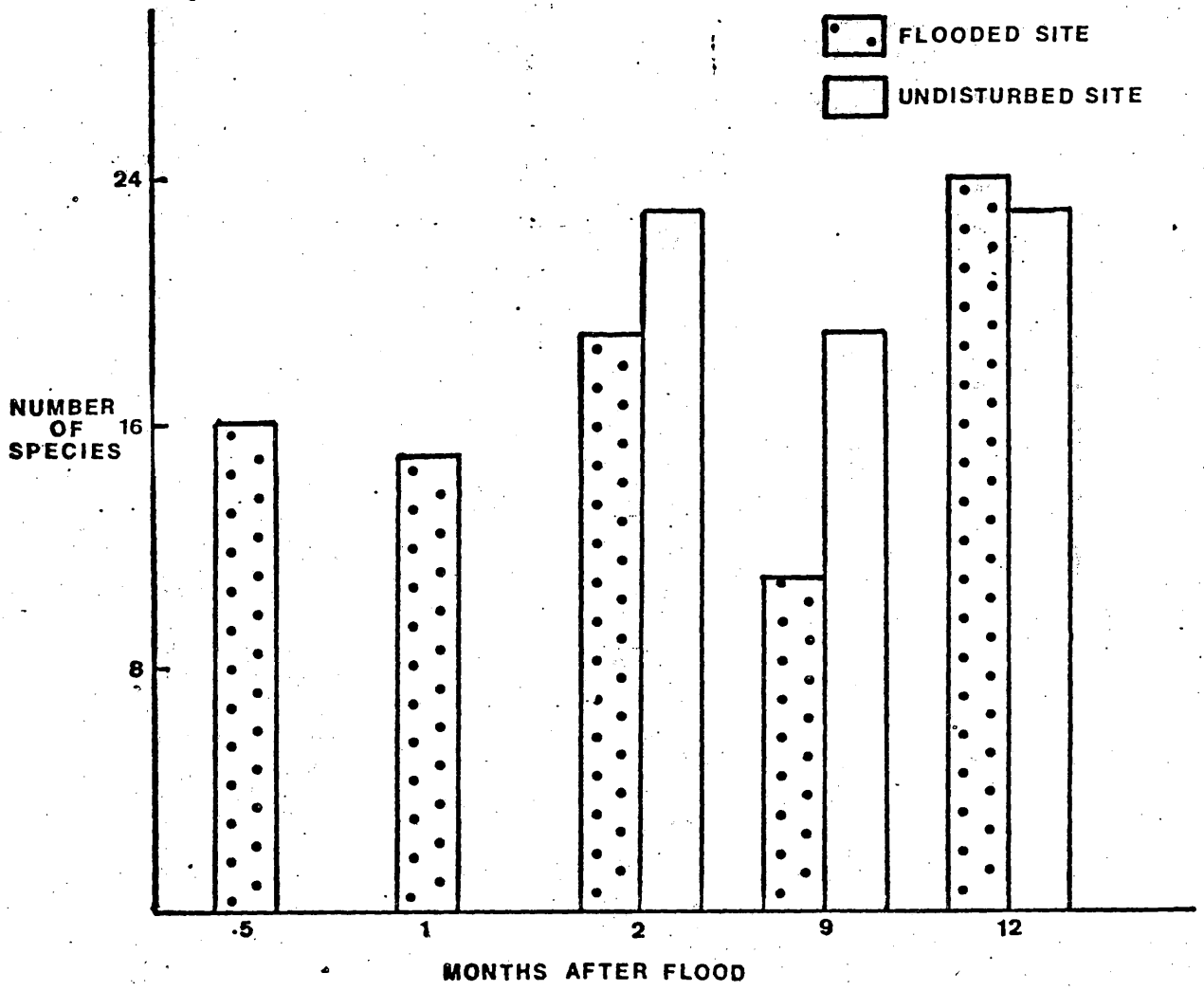

FLOODED SITE
UNDISTURBED SITE
80
60
40
20
DRY WT
mg
*
*
N.S.
.5
1
2
9
12
MONTHS AFTER FLOOD

Figure 4. Number of species of Ephemeroptera, Plecoptera, Trichoptera, and Coleoptera collected in 12 Surber samples at the 250 m-below and undisturbed study sites.


FLOODED SITE
UNDISTURBED SITE
24
16
8
NUMBER OF SPECIES
.5
1
2
9
12
MONTHS AFTER FLOOD